

AD-A125 151

MERCURY AND NEW IMPOUNDMENTS(U) NORTH CAROLINA UNIV AT
CHAPEL HILL DEPT OF ENVIRONMENTAL SCIENCES AND
ENGINEERING C M WEISS ET AL. MAY 78 ESE-533

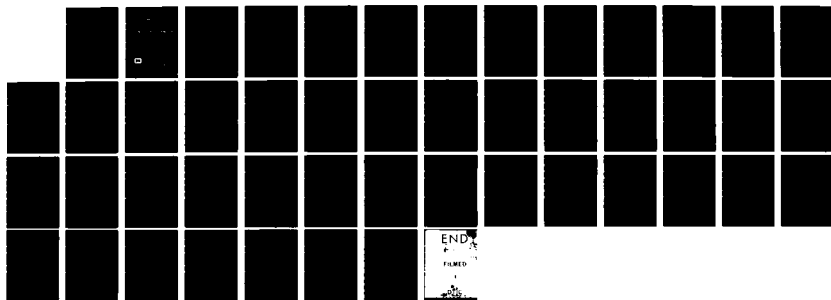
1/1

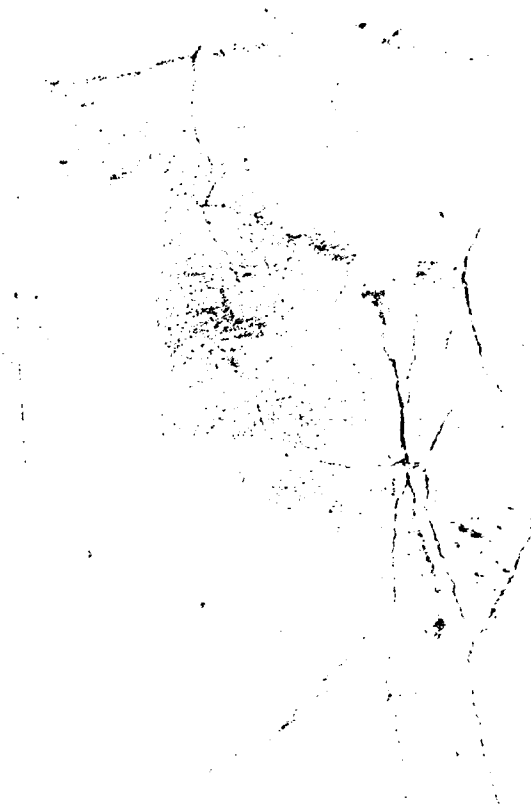
UNCLASSIFIED

DACH54-77-M-1551

F/G 13/2

NL



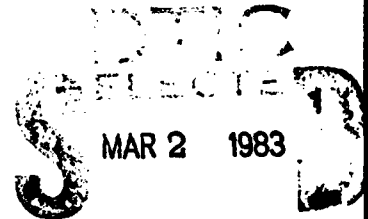


© Springer 2006

AD A125101

MERCURY

AND



A

NEW IMPOUNDMENTS

**B. EVERETT JORDAN AND FALLS LAKE
SUB - IMPOUNDMENTS**

This document has been approved
for public release and sale; its
distribution is unlimited.



**US Army Corps
of Engineers**

Wilmington District

**MAY
1978**

DTIC FILE COPY

3 023 212

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A125151	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Mercury and New Impoundments B. Everett Jordan and Falls Lake Sub-impoundments		5. TYPE OF REPORT & PERIOD COVERED Final Report
		6. PERFORMING ORG. REPORT NUMBER ESE No. 533
7. AUTHOR(s) Charles M. Weiss & Andrew E. Bond		8. CONTRACT OR GRANT NUMBER(s) DACW 54-77-M-1551
9. PERFORMING ORGANIZATION NAME AND ADDRESS Department of Environmental Sciences & Engineering School of Public Health University of North Carolina at Chapel Hill Chapel Hill, NC 27514		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, Wilmington PO Box 1890 Wilmington, NC 28402		12. REPORT DATE May 1978
		13. NUMBER OF PAGES 43
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES Available from National Technical Information Service 5285 Port Royal Road Springfield, VA 22151		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Mercury New Reservoirs Water Supply Reservoirs Soil and Plant Specimens		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Two small reservoirs were used in an investigation to determine the concentrations of mercury in the impounded water as each basin filled. There was an initial sampling of soil and plant specimens from the pre-flooded reservoir sites to establish background levels of mercury. The reservoir waters were then sampled and analyzed for mercury, as well as other limnological parameters for several months after filling.		

Mercury analyses on the water samples of these reservoirs showed in both instances, a consistent pattern of most samples below the detection limit of the analytical procedure of 0.20 ppb. But in both reservoirs, several sets of samples did have mercury concentrations that were above the detection limit and permit comparison. These samples showed that the waters of Beaverdam had mean concentrations of 0.40 ppb in the surface waters and 0.47 in the bottom samples, whereas the Parker Creek concentrations had a mean of 0.27 ppb at the surface and 0.28 at the bottom.

When examined in the time sequence post closure, both impoundments had a change in mercury concentration, in the water samples, that followed a strikingly similar pattern. This was a rise from less than detectable levels, to their peak concentrations and then a drop once more to less than detectable levels. In both reservoirs, the time scale was the same, about 140-150 days to the maximum mercury concentrations. This would suggest a mechanism of release of mercury from plant debris and the soils that require 5-6 months but ceases once the readily available sources of mercury are depleted.

Overall, the mercury content of the soil cores from both Beaverdam and Parker Creek had on the average about the same mercury content, 42.0 ppb for the former and 45.4 ppb for the latter. In the vertical profile of the bottom cores, analyzed in three 5cm segments, at the 18 core sites of the Beaverdam basin, triplicate cores at each site, the mercury content of 8 sites was highest in the top segment grading to lower concentrations at deeper levels. Eight of the sites had the reversed pattern, lower concentrations at the top and higher values below and two sites were about the same at the three core depths analyzed. In the Parker Creek basin, of the eight sites cored, seven had a higher to lower mercury content from the top down and one had the reversed pattern.

Correlation of the mercury content with the percent of sand, silt, clay, and organic matter in the soil cores indicated that the quantity of mercury was most strongly associated with the richness of the organic content. This is probably a basic reason for the variation in quantity of mercury at individual core sites, ranging from levels that were below the limits of detection to values as high as 86 ppb at a Beaverdam core site and 101 ppb at a Parker Creek location.

Plant specimens located at these core sites showed a very high degree of correlation between the mercury content of the plant tissue and the mercury content of the top 5cm of the soil cores at the point of collection. The sedges and Juncaceae accumulated (mean values) 347 ppb and 279 ppb of mercury, respectively, as compared to 237 ppb for the grasses and 148 ppb for several specimens of broad-leaf herbs.

MERCURY AND NEW IMPOUNDMENTS

**A Report to the
Wilmington District
U.S. Army Corps of Engineers**

Contract DACW 54-77-M-1551

by

**Charles M. Weiss
Professor of Environmental Biology**

with

**Andrew E. Bond
Research Assistant**



**Department of Environmental Sciences and Engineering
School of Public Health
University of North Carolina at Chapel Hill
Chapel Hill, N.C.**

May 1978

ESE No. 533

Table of Contents

List of Tables	ii
List of Figures	iii
Summary and Conclusions	iv
Introduction	v
Methods and Materials	2
Results and Discussion	10
Mercury in Water	18
Soil Core Analyses	24
Mercury in Plant Tissues	31
References	38

List of Tables

		Page
1.	Physical and Chemical Water Quality Characteristics Beaverdam Creek Basin	11
2.	Physical and Chemical Water Quality Characteristics Parker Creek Basin	15
3.	Mean Values - Water Quality Parameters	19
4.	Beaverdam Creek Reservoir, Mercury micrograms/liter	20
5.	Parker Creek Reservoir, Mercury micrograms/liter	22
6.	Mean Values and Standard Deviation of all Water Samples with Measurable Amounts of Mercury (>0.20 ppb) on Date of Samples	23
7.	Beaverdam Reservoir, Soil Core Analysis (Percent Composition) and Mercury Content (ppb)	26
8.	Parker Creek Reservoir, Soil Core Analysis (Percent Composition) and Mercury Content (ppb)	29
9.	Correlation Coefficients, Mercury Concentration and Percent Soil Composition, Overall and at Three Core Depths .	32
10.	Mercury in Plant Samples Collected in Beaverdam and Parker Creek Basins	34
11.	Mercury Content of Plant Samples Arranged in Increasing Order of Concentration and Compared to Originating Soil Mercury Concentrations	36

List of Figures

	Page
1. Location map Beaverdam Reservoir	3
2. Beaverdam Reservoir, Sampling Transects and Stations	4
3. Location map Parker Creek Reservoir	5
4. Parker Creek Reservoir, Sampling Transects and Stations . .	6
5. Relationship of Percent of Samples Greater than Mercury Detection Limit, and Absolute Mercury Concentration with Days Post Closure of Beaverdam and Parker Creek Reservoirs .	25
6. Relationship of Mean Values of Mercury in Plant Samples and Mean Values of Originating Soil Samples Derived From Rank Clustering	37

SUMMARY and CONCLUSIONS

Two small reservoirs were used in an investigation to determine the concentrations of mercury in the impounded water as each basin filled. There was an initial sampling of soil and plant specimens from the pre-flooded reservoir sites to establish background levels of mercury. The reservoir waters were then sampled and analyzed for mercury, as well as other limnological parameters for several months after filling.

One impoundment, Beaverdam, is a temporary water supply reservoir constructed by the City of Raleigh on Beaverdam Creek to augment low flow in the Neuse River, when necessary. The Neuse River is one of the water supply points for Raleigh. The other impoundment, Parker Creek, is an arm of the B. Everett Jordan Reservoir that is cut off from the main reservoir area by a road causeway. Parker Creek Reservoir has been filled to serve as a recreational impoundment for Chatham County. Beaverdam reservoir started to fill in the summer and Parker Creek in the late fall of 1976.

Systematic limnological sampling revealed the usual seasonal pattern of physical and chemical change in both reservoirs. One unusual feature noted in both basins was a shift in pH from the usual neutral to slightly alkaline range to acidic values that are generally associated with acid swamp waters. Paralleling this change was a rise in conductivity suggestive of waters rich in ionic content.

Mercury analyses on the water samples of these reservoirs showed in both instances, a consistent pattern of most samples below the detection limit of the analytical procedure of 0.20 ppb. But in both reservoirs, several sets of samples did have mercury concentrations that were above the detection limit and permit comparison. These samples showed that the waters of Beaverdam had mean concentrations of 0.40 ppb in the surface waters and 0.47 in the bottom samples, whereas the Parker Creek concentrations had a mean of 0.27 ppb at the surface and 0.28 at the bottom.

When examined in the time sequence post closure, both impoundments had a change in mercury concentration, in the water samples, that followed a strikingly similar pattern. This was a rise from less than detectable levels, to their peak concentrations and then a drop once more to less than detectable levels. In both reservoirs, the time scale was the same, about 140-150 days to the maximum mercury concentrations. This would suggest a mechanism of release of mercury from plant debris and the soils that requires 5-6 months

but ceases once the readily available sources of mercury are depleted.

Overall, the mercury content of the soil cores from both Beaverdam and Parker Creek had on the average about the same mercury content, 42.0 ppb for the former and 45.4 ppb for the latter. In the vertical profile of the bottom cores, analyzed in three 5cm segments, at the 18 core sites of the Beaverdam basin, triplicate cores at each site, the mercury content of 8 sites was highest in the top segment grading to lower concentrations at deeper levels. Eight of the sites had the reversed pattern, lower concentrations at the top and higher values below and two sites were about the same at the three core depths analyzed. In the Parker Creek basin, of the eight sites cored, seven had a higher to lower mercury content from the top down and one had the reversed pattern.

Correlation of the mercury content with the percent of sand, silt, clay and organic matter in the soil cores indicated that the quantity of mercury was most strongly associated with the richness of the organic content. This is probably a basic reason for the variation in quantity of mercury at individual core sites, ranging from levels that were below the limits of detection to values as high as 86 ppb at a Beaverdam core site and 101 ppb at a Parker Creek location.

Plant specimens collected at these core sites showed a very high degree of correlation between the mercury content of the plant tissue and the mercury content of the top 5cm of the soil cores at the point of collection. The sedges and Juncaceae accumulated (mean values), 347 ppb and 279 ppb of mercury respectively as compared to 237 ppb for the grasses and 148 ppb for several specimens of broad-leaf herbs.

RECOMMENDATION

It would be extremely useful to confirm with greater precision this apparent build-up of mercury into the water about 5-6 months post filling of a reservoir basin. This followup study could be carried out in other segments of B. Everett Jordan Reservoir, with soil coring and plant sampling, being made when tree removal is completed. Similarly, the time post flooding could be determined with greater precision at different locations in the reservoir area. Subsequent water sampling in the newly flooded basin should be at least at a two-week frequency.

INTRODUCTION

The concern over mercury in water and particularly waters to be used as water supplies has in the past decade, on occasion, reached unusual levels following reports of pollution involving mercury. Extreme cases included the seafood contamination by industrial wastes in Minamata, Japan and other industrial accidents which contaminated grain feeds with mercurial fungicides. Natural levels of mercury in bottom sediments as well as mercury levels introduced through industrial operations may be converted by microorganisms to more soluble methylated forms and thus, facilitate its entry into food chains with marked accumulation in tissues (D'Itri, 1973). Safe levels of mercury for ingestion via foods indicate that maximum dietary intakes in drinking water be held to a concentration of 0.002 mg/l (2.0 µg/l) (Miettinen, 1977). Even if fish, which bioaccumulate mercury, were to be consumed at sufficiently high daily rates that would expose the individual to dangerous mercury concentrations, by including a safety factor of 10, fish ingestion would necessarily be limited to 60 grams per day containing 0.5 µg/g of Hg (D'Itri et al., 1978).

In the litigation concerning the completion of the B. Everett Jordan Project, one of the important contentions of the plaintiffs was that the mercury concentrations to be expected in the impoundment would reduce its usefulness as a potential water supply. Concentrations of mercury in the streams that would feed water into the impoundment, if the gates at B. Everett Jordan Dam would be closed, ranged over the several years of sampling, from 3.0 to 80.0 µg/l (Weiss, Yocum and Minogue, 1972). These concentrations did not appear to be systematic in their distribution so that no one water sampling station was highlighted as consistently having higher than average background concentrations of mercury. Discussion of this issue centered on safe levels of mercury in water supplies as well as potential levels to be expected in the B. Everett Jordan Reservoir if the basin should be filled. One issue that had not been resolved at the time of the court hearings was the magnitude of the natural background levels in the soils of the basin and how the mercury content of these soils might contribute to the overall levels of mercury in the overlying waters.

The question of the relationship of mercury in soil or sediments and mercury in overlying waters was examined locally when it became possible to systematically sample the bottom soils of two local sub-impoundments just prior to their filling in the summer and fall of 1976. In the one

instance, a sub-impoundment had been constructed on Beaverdam Creek, a stream flowing into the Neuse River. This reservoir is a temporary storage basin for the water supply needs for the city of Raleigh. The water stored is to supplement stream flow in the Neuse River under extreme low flow conditions such as that developed in the summer of 1975. This sub-impoundment will be inundated on completion of the Falls of the Neuse Project. The larger impoundment will then serve as a water source for the water supply requirements for the city of Raleigh. In the second instance, the Parker Creek arm of the B. Everett Jordan Reservoir, due to its location and isolation from the main lake by the U.S. 64 causeway crossing has been identified as a recreational area and assigned to the county of Chatham for its use for recreational purposes. Since its recreational uses, fishing and boating, were not a point of contention in the litigation on B. Everett Jordan Reservoir, the closing of the gate in the drainage culvert under U.S. 64 was allowed and the Parker Creek basin filled in the late fall of 1976, following an extended dry period.

In both the Beaverdam and Parker Creek sub-impoundments, soil corings and plant samples were taken prior to flooding. Water sampling was carried out as the impoundment filled and for a period of several months thereafter, Figures 1 to 4 provide location maps as well as sampling locations on each of these sub-impoundments.

METHODS and MATERIALS

Beaverdam Creek Basin

Ground Survey - The initial ground survey of this basin was conducted on September 18, 1976. The purpose of this survey was to determine the extent of flooding in the basin and the selection of a practical sampling scheme.

The main basin contained a pool approximately 250 yards wide at the dam and extending $\approx 3/4$ miles up the basin. The depth of the water varied from one to six feet. (The depth gauge at the dam site indicated 15 feet below full pool or 244 ft. m.s.l.) The main pool was relatively clear of visible vegetation in contrast to the upper basin which had a heavy plant cover (no bare soil).

The basin from the dam site north to Beaverdam Creek Road (Wake County No. 1900) could not be crossed by wading due to the depth of water. Consequently, it was decided that a boat would be required for sampling both sediment cores and water samples in the lower transects. The upper basin

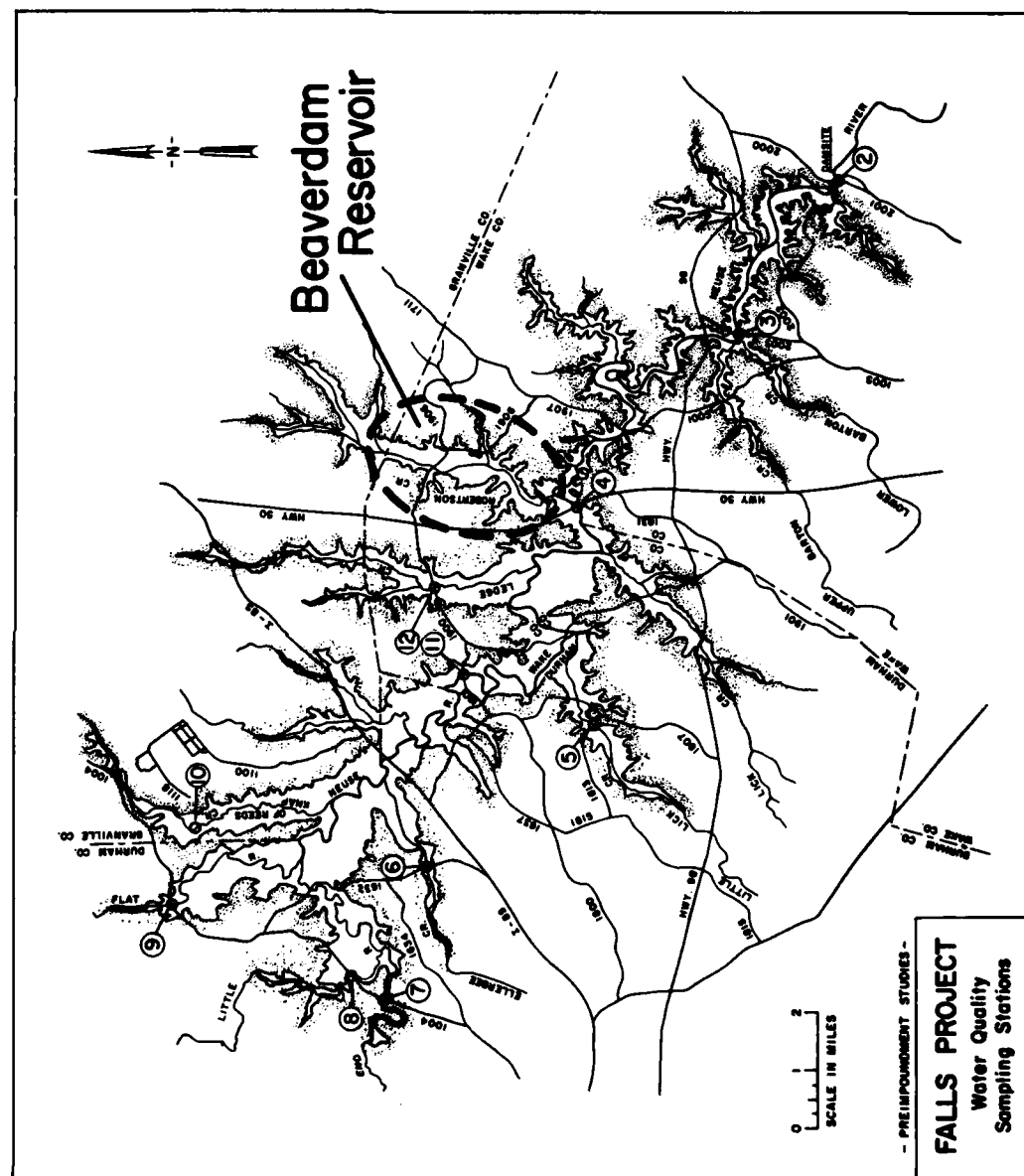


Figure 1. Location map Beaverdam Reservoir

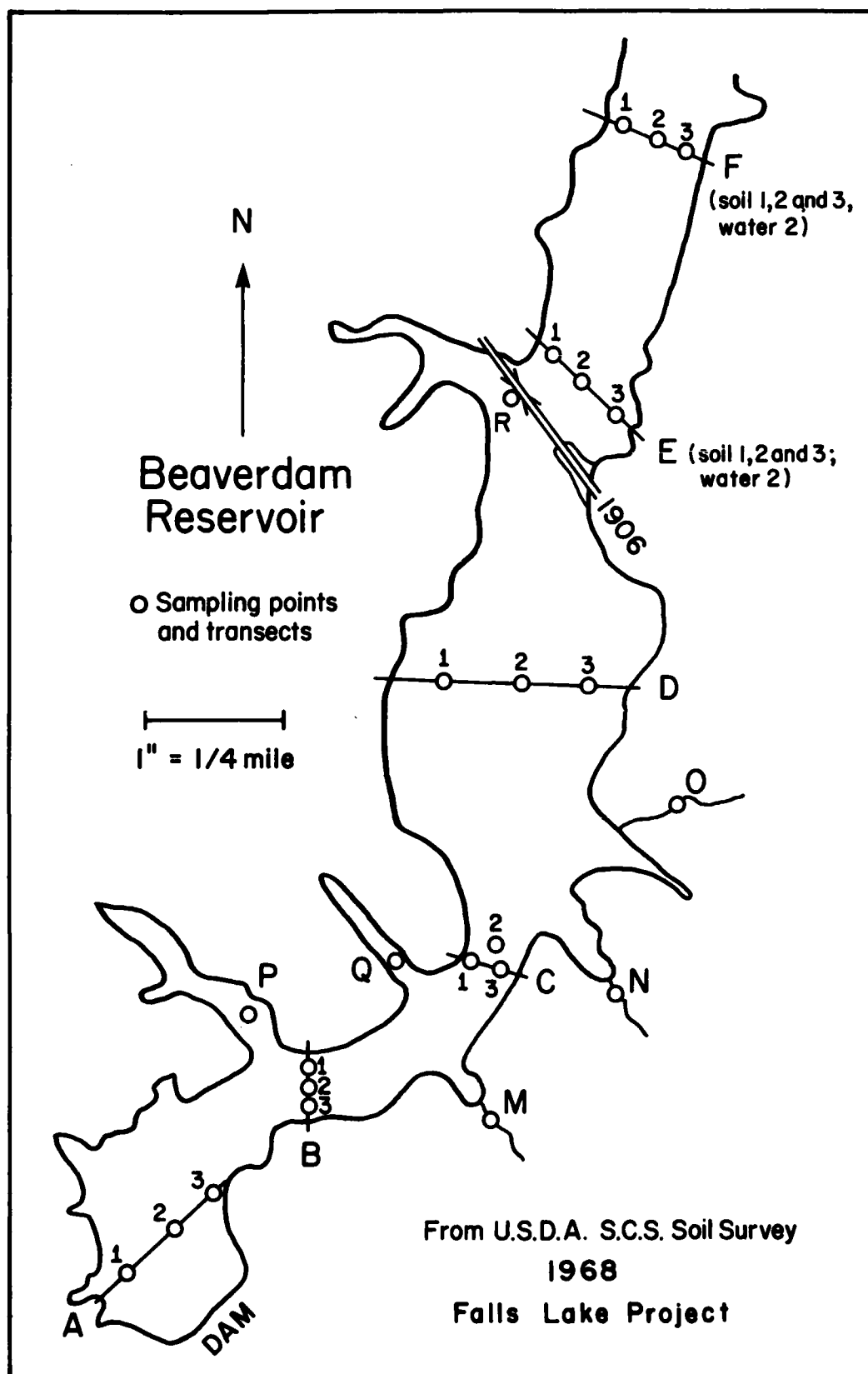


Figure 2. Beaverdam Reservoir, sampling transects and stations

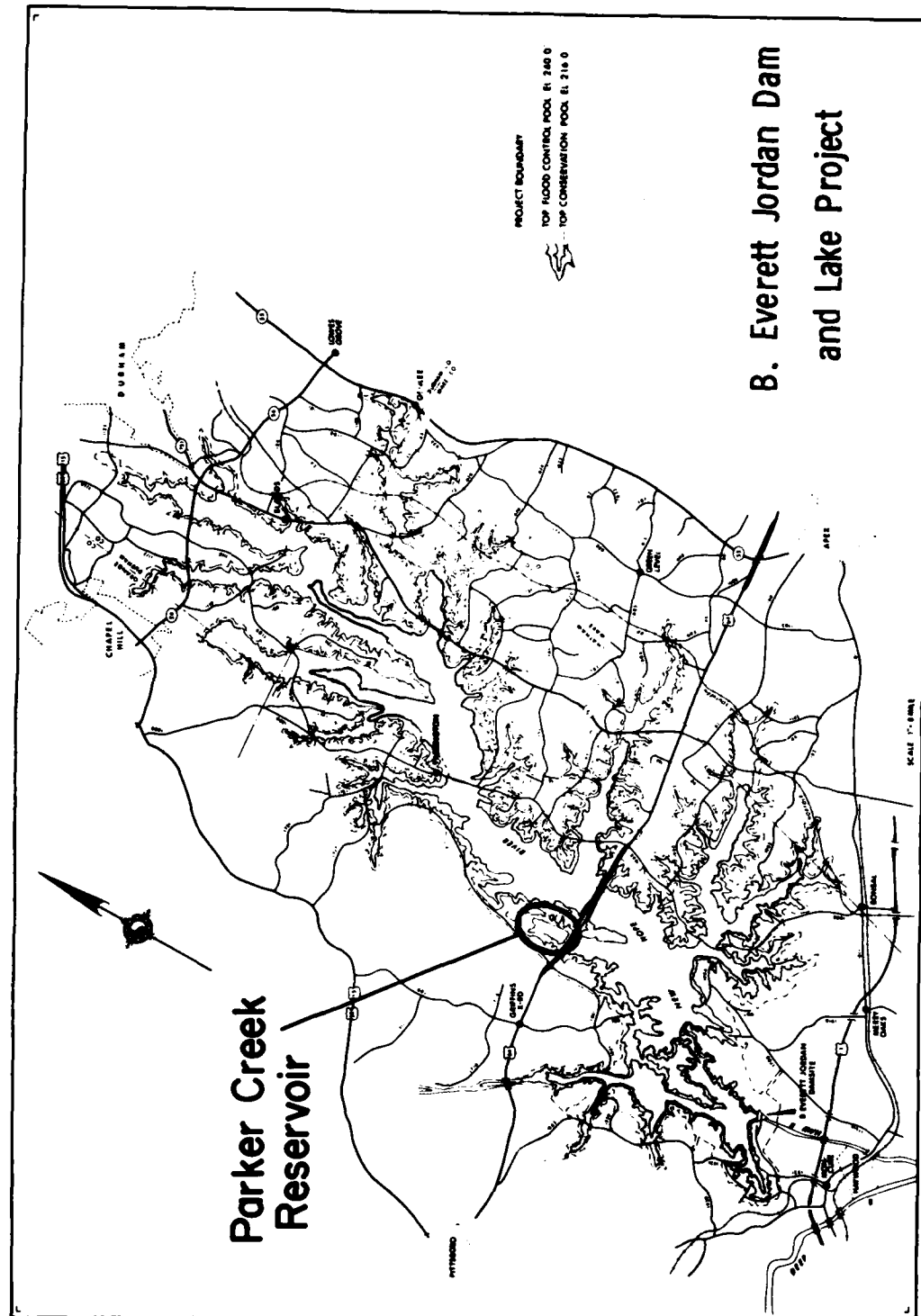


Figure 3. Location map Parker Creek Reservoir

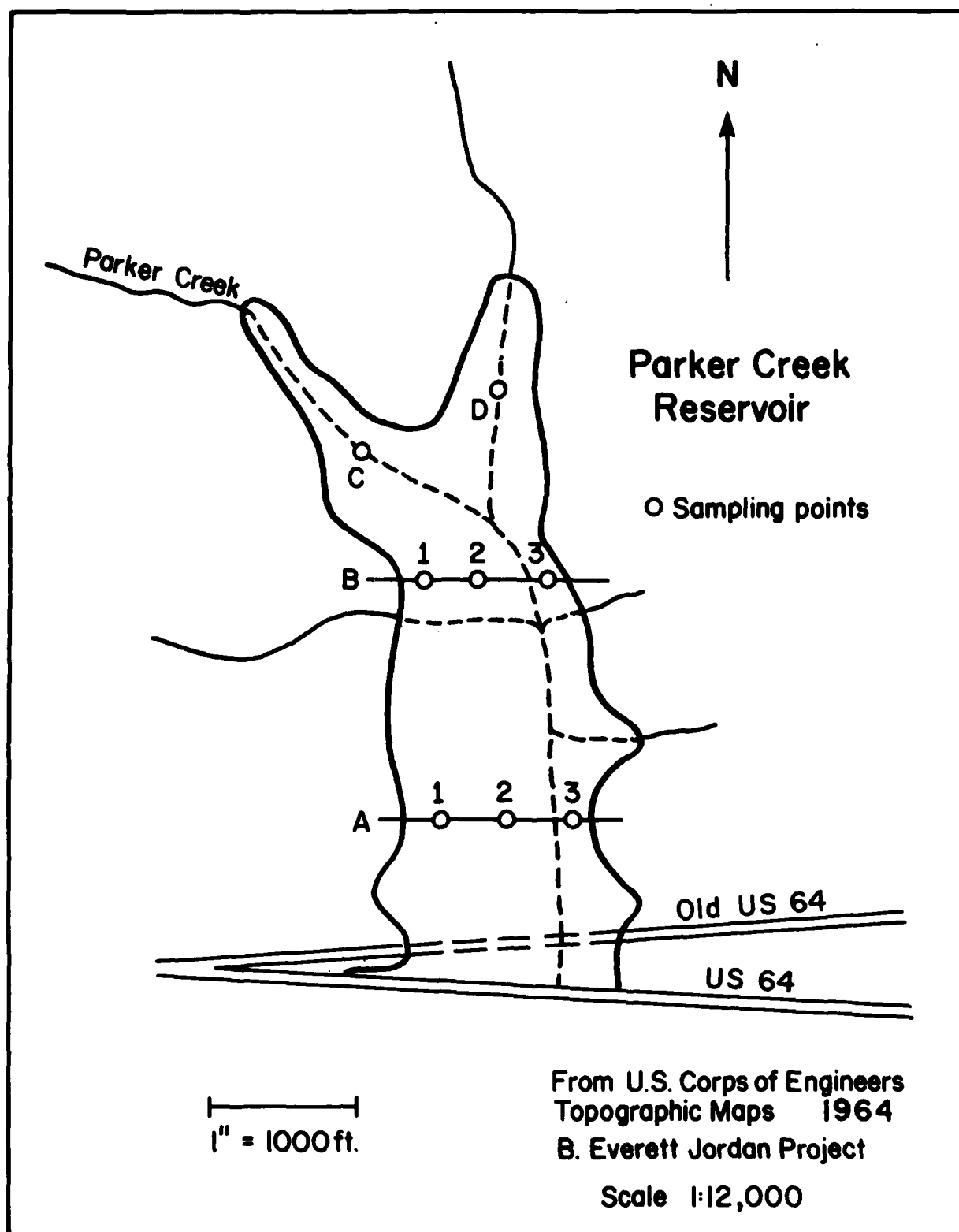


Figure 4. Parker Creek Reservoir, sampling transects and stations

could be sampled on foot.

Sampling Procedure - Six transects across the basin were established each containing three sampling points. Three core samples were taken at each sampling location. The core holes formed a triangle \approx 1 meter on each side. The core tubings were varying lengths of lexane tubing (Commercial Plastics, Raleigh, North Carolina) which were hand-driven into the ground to a minimum depth of 15 centimeters. Within the triangle formed by the location of the sediment cores, samples of vegetation were collected, labeled and placed in plastic bags for storage. The sediment core tubes were labeled, stoppered and frozen. The vegetation samples were also frozen until analyzed.

A total of six sampling trips, September 21, 1976 through October 7, 1976, were required to complete the collection of both sediment and initial water samples. A 12-foot aluminum boat with 15 horsepower engine was used to collect the mid-transect core and water samples as well as all future water samples over the period of the report. Water samples from the impounded water were collected with a 3-liter Kemmerer sampler. They were placed in pre-washed 1 liter polyethylene bottles which had been rinsed with concentrated nitric acid. Each sample bottle was rinsed with a portion of the water sample before adding a total of 10 ml nitric acid and potassium dichromate solution. The acid and dichromate were added to each bottle and mixed prior to the addition of 1 liter of water (Lo and Wai, 1975). Stream samples were similarly collected and preserved. All water samples were stored at room temperature until analyzed.

Parker Creek Basin

Ground Survey - The initial ground survey of this basin was conducted on October 13, 1976. At this time, the proposed impoundment contained water only in a small area between old and new U.S. 64. The entire basin upstream of old U.S. 64 could be sampled by foot. The basin was heavily covered with plant growth (no bare soil) and flowing streams were entering the basin on the day of bottom core sampling.

Sampling Procedure - Three transects across the basin were established, two containing three sampling points, with the third containing only two points. The procedure for collection of water, soil cores and vegetation samples for this basin was the same as for the Beaverdam Creek Basin. All

sediment and vegetation samples were collected on October 16, 1976 and frozen for future analysis.

Sample Preparation

The water samples were preserved with nitric acid/dichromate. Vegetation samples were air dried at room temperature for seven days prior to grinding in a Wylly Mill to a 40 mesh size.

Sediment cores were cut when partially thawed into three sections, 0-5, 5-10 and 10-15 cm depths. Each portion was then thawed completely and split into three equal samples for size fractionation, and determination of water and organic content. The technique of core and quartering was used for this separation (Ingram, 1971). The sub-samples were then placed in plastic dishes for storage and returned to the freezer until analyzed.

Analytical Procedure

The analytical procedure for the determination of mercury in water included the digestion of the samples between 50-60°C with a sulphuric acid-nitric acid (2+1), and subsequent oxidation with permanganate and persulfate solution (Agemian and Chau, 1976). A 100 ml unfiltered sample was used. All standards were treated in the same manner as the water samples. For sediment samples, a sediment size of 1.00-1.10 gm of wet sediment was used. The dry weight for the determination of the mercury concentration was calculated using the water content determination made on a portion of the same sub-sample.

Determination of Percent Moisture and Percent Organic Matter

An approximate 1 gm sample of core was weighed in a pre-weighed crucible and dried at 105°C for 24 hours. The dried sample was returned to room temperature in a dessicator and reweighed. This provided both water content and dry weight of sample. The crucible was then fired in muffle furnace at 550°C for one hour. It was cooled in a dessicator to replace water of hydration and dried at 105°C for 24 hours before cooling to room temperature and final reweighing. The loss of weight in the furnace was considered to be organic content (Gross, 1971).

Particle Size Analysis

Dry core sample was disaggregated with a wood rolling pin on a large sheet of high gloss paper. This prepared sample was dry sieved at room temperature through 2 #230 standard soil sieve. The sand fraction retained in the sieve was weighed. The sieved fraction was analyzed for silt and clay content (Ingram, 1971).

Quality Control

High purity certified reagents were used for all analyses. A mercury standard solution, mercuric or mercurous [$\text{Hg}(\text{NO}_3)_2$ or HgNO_3] nitrate of 1000 mg/l solution was prepared. This was used to prepare concentrations of 0.2, 0.5, 1.0, 1.5 and 2.0 $\mu\text{g}/\text{l}$ for use as standards. The respective aliquots were added to 100 ml of 1% nitric acid solution. All standards were run in 4-6 replicates. Standards were included in the beginning, the middle and at the conclusion of the sample analyses. This procedure was used to monitor instrument performance. (Mercomatic Model 2006-1, Anti-Pollution Tech. Corp., Hubbard, Michigan). Methyl mercury spikes were used to monitor the recoverability of methyl mercury. The spikes were analyzed in triplicate.

RESULTS and DISCUSSION

The presentation of data derived from the analysis carried out on the water, soil and plant materials from the two sub-impoundments will first examine the findings for mercury in the waters of the two basins. This will be followed by presentation of results and discussion of the soil and plant analyses respectively.

The waters of the Beaverdam reservoir were sampled over a period of eight months and those of Parker Creek reservoir for four months. The shorter interval for the latter resulted from a delay in closing the culvert gate in order to allow the basin to fill. When closure did occur, it coincided with a prolonged dry period and insufficient runoff to fill the basin. When the basin finally filled at Parker Creek, an extreme freeze followed shortly afterwards effectively preventing water sampling until the spring thaw.

Water sampling in vertical profile was carried out along the transects used to locate the bottom samples. Table 1 (Beaverdam) and 2 (Parker Creek) describe seasonal water quality changes characteristic of small basins of this region as well as highlighting conditions that were unexpected.

The water of the Beaverdam reservoir followed the usual seasonal pattern of this area. Following isothermal conditions in the winter, rapid thermal stratification with some deoxygenation of the deeper waters developed. The decrease of oxygen in the deep water persisted until the oxygen content of the bottom water was nearly zero, particularly in the deeper portions along the A and B transects late in July, 1977. However, at no time was there extensive development of actual anerobic water covering the bottom. Of somewhat more interest and significance, was the shift in pH of the water from approximately neutral to a consistent pattern of acidity. This pH range usually describes quality associated with the more acid waters of swamps. In parallel with this shift towards acidity was a marked and strong increase in conductivity; a rise which is further suggestive of waters rich in ionic content and possibly more characteristic of waters of long retention (tables 1 and 2). Except for several surface samples of the A transect, May 20 samples, no other samples showed the slightly alkaline pHs normally associated with levels of high biological activity, active photosynthesis.

Observations in the Parker Creek reservoir, starting early in March, described a similar series of events with thermal stratification showing rapid development and deoxygenation of the deep waters below the thermocline. As in the Beaverdam basin, the shift in pH to the acid range while evident in

TABLE 1
PHYSICAL and CHEMICAL WATER QUALITY CHARACTERISTICS
BEAVERDAM CREEK BASIN

December 22, 1976											
STATIONS	Depth-M	Temp°C	DO mg/l	pH	Cond. µmhos	STATIONS	Depth-M	Temp°C	DO mg/l	pH	Cond. µmhos
A-1	0	5.1	9.8	7.0	78	M	0	5.5	8.8	6.6	76
	1.5	5.0	9.8	7.0	78		1.5	4.6	8.5	6.6	75
	3.0	5.0	10.0	7.1	78		2.7	4.5	8.5	6.6	75
A-2	0	5.3	9.7	7.0	79	N	0	4.3	10.2	6.4	70
	1.5	5.1	9.6	7.0	79		1.5	4.0	10.2	6.4	70
	3.0	5.0	9.6	7.0	79	O	0	3.5	10.5	7.0	70
	4.0	5.0	9.5	7.0	79		1.5	3.5	10.4	7.0	70
A-3	0	5.5	9.7	6.9	80	P	0	5.0	9.0	6.8	75
	1.5	5.2	9.6	6.9	80		1.5	4.5	9.0	7.0	75
	3.0	5.1	9.5	7.0	80		2.6	4.5	8.8	7.0	75
	4.0	5.1	9.3	6.9	82	Q	0	5.5	8.6	6.6	76
B-1	0	5.5	8.8	6.5	74		1.5	4.8	8.6	6.6	75
	1.5	5.1	8.5	6.6	75						
	3.0	5.0	8.6	6.6	75						
	3.4	5.0	8.4	6.7	76						
B-3	0	5.1	8.9	6.6	75						
	1.5	5.0	8.7	6.7	75						
	3.0	4.9	8.7	6.7	75						
	3.7	4.9	8.7	6.7	75						
C-1	0	5.3	9.3	6.4	72						
	1.5	5.0	9.4	6.5	72						
	2.5	4.6	9.4	6.5	72						
C-3	0	4.7	9.9	6.4	70						
	1.5	4.5	9.8	6.4	69						
	3.0	4.5	9.5	6.5	70						
D-1	0	4.7	9.2	6.3	71						
	1.5	4.7	9.1	6.3	71						
D-2	0	5.0	9.9	6.3	71						
	1.5	5.0	9.5	6.3	71						
	2.0	4.9	9.3	6.3	71						
D-3	0	4.5	10.0	6.4	72						
	1.5	4.5	9.9	6.4	72						
	2.6	4.5	9.9	6.4	72						

Temperature, DO, pH and conductivity were measured with Hydro Lab^R Model 6D probes. Measurement precision: Temp., 0.1°C; DO, 0.1 mg/l; pH, 0.1 pH unit; cond., 1 µmhos/cm.

TABLE 1 - (continued)

March 17, 1977

STATIONS	Depth-M	Temp°C	DO mg/l	pH	Cond.	STATIONS	Depth-M	Temp°C	DO mg/l	pH	Cond.
					µmhos						µmhos
A-1	0	15.5	8.8	6.6	70	R	0	15.5	7.2	6.3	66
	1.5	15.0	8.7	6.6	69		1.5	14.5	6.3	6.2	65
	3.0	15.0	8.6	6.6	69	E	0	16.5	7.3	6.3	69
	4.1	10.0	4.6	6.4	77		1.5	14.9	6.5	6.2	74
A-2	0	15.5	8.8	6.6	70	F	0	15.5	8.2	6.3	77
	1.5	15.1	8.7	6.6	67		1.5	-	-	-	-
	3.0	14.0	7.9	6.5	70	M	0	15.5	8.3	6.5	68
	4.5	10.0	5.1	6.4	76		1.5	15.5	7.9	6.5	68
	5.0	9.5	4.9	6.4	78		2.9	13.0	6.0	6.3	73
A-3	0	15.0	8.8	6.6	69	N	0	16.1	8.8	6.5	68
	1.5	15.0	8.7	6.6	68		1.5	15.0	8.6	6.4	69
	3.0	14.0	7.9	6.6	71		2.9	13.5	4.9	6.3	73
	4.5	9.9	5.6	6.4	78	O	0	16.5	8.2	6.5	71
	5.1	9.3	5.0	6.4	79		1.5	15.5	7.7	6.5	68
B-1	0	15.8	8.5	6.6	67		2.0	14.9	7.2	6.5	69
	1.5	15.5	8.3	6.5	66	P	0	15.5	8.6	6.6	69
	3.0	12.5	4.9	6.4	72		1.5	15.1	8.3	6.6	69
	4.2	10.6	2.0	6.3	78		3.0	12.1	4.1	6.3	72
B-3	0	16.0	8.8	6.7	67		4.1	10.5	0.5	6.3	82
	1.5	15.3	8.9	6.6	71	Q	0	15.8	8.3	6.6	68
	3.0	12.6	7.6	6.4	74		1.5	15.5	8.2	6.5	68
	4.5	10.0	4.9	6.3	80		2.7	13.2	2.0	6.2	74
	5.0	9.5	2.8	6.3	81						
C-1	0	16.2	7.8	6.6	68						
	1.5	15.5	7.8	6.4	68						
	3.0	11.5	3.4	6.3	75						
C-3	0	16.0	8.2	6.6	68						
	1.5	15.5	7.8	6.6	67						
	3.0	11.5	4.3	6.3	76						
	3.5	11.0	2.9	6.3	79						
D-1	0	16.0	8.4	6.3	67						
	1.5	15.5	8.6	6.3	67						
	2.8	13.5	1.8	6.2	76						
D-2	0	16.0	8.4	6.3	68						
	1.5	15.3	8.6	6.3	67						
	2.8	13.5	1.8	6.2	73						
D-3	0	16.0	8.2	6.5	71						
	1.5	15.5	8.5	6.4	70						
	3.0	13.3	2.0	6.3	91						

TABLE 1 - (continued)

May 20, 1977											
STATION	Depth-M	Temp°C	DO mg/l	pH	Cond. μmhos	STATION	Depth-M	Temp°C	DO mg/l	pH	Cond. μmhos
A-1	0	26.5	8.3	7.2	92	R	0	25.0	7.0	6.9	110
	1.5	26.0	8.2	7.3	90		1.5	24.0	5.3	6.6	110
	3.0	21.0	4.5	6.2	89	E	0	25.0	5.6	6.8	160
	4.0	16.5	2.2	6.3	110		0.5	24.6	4.7	6.4	150
A-2	0	26.0	8.7	7.3	89	F	0	25.0	7.3	7.0	130
	1.5	25.8	8.3	7.2	87		1.5	23.0	1.1	6.4	130
	3.0	20.8	3.6	6.1	83		2.0	19.8	0.4	6.1	240
	4.5	15.0	2.1	6.5	100	M	0	25.7	7.6	6.7	88
A-3	0	26.0	7.6	7.6	91		1.5	24.0	7.2	6.7	89
	1.5	25.3	7.2	7.2	92		2.5	21.0	1.5	6.2	100
	3.0	20.1	3.1	6.3	90	N	0	25.6	7.6	6.8	94
	4.5	15.0	0.5	6.8	110		1.5	23.0	5.9	6.6	91
	5.0	13.5	0.4	6.9	120		2.5	21.0	0.2	6.2	95
B-1	0	25.5	8.2	7.1	100	O	0	26.0	7.8	6.9	91
	1.5	25.0	8.1	7.0	100		1.5	24.5	6.4	6.5	90
	3.0	18.0	2.5	6.4	120		2.0	22.8	1.4	6.2	115
	4.5	14.3	1.3	6.5	150	P	0	26.0	8.3	7.2	79
B-3	0	25.5	7.9	6.9	93		1.5	25.0	8.0	6.9	89
	1.5	25.1	7.8	6.7	91		3.0	21.5	1.8	6.3	110
	3.0	20.0	1.2	5.9	88	Q	0	25.7	8.1	7.0	89
	4.5	15.1	1.2	6.5	120		1.5	24.8	7.7	6.9	90
C-1	0	25.6	8.0	7.1	95		2.5	20.5	1.5	6.2	100
	1.5	24.5	6.9	6.6	92	C-3	0	25.5	8.1	7.0	110
	3.0	18.5	0.8	6.3	110		1.5	24.0	7.2	6.8	110
C-3	0	25.5	8.1	7.0	110		3.0	18.5	0.4	6.4	105
	1.5	24.0	7.2	6.8	110	D-1	0	24.8	7.5	6.8	100
	3.0	18.5	0.4	6.4	105		1.5	24.5	7.5	6.7	92
D-1	0	24.8	7.5	6.8	100		2.2	22.2	1.0	6.2	110
	1.5	24.5	7.5	6.7	92	D-2	0	25.0	7.6	6.8	100
	2.2	22.2	1.0	6.2	110		1.5	22.5	3.0	6.2	105
D-2	0	25.0	7.6	6.8	100		2.5	20.0	0.4	6.3	120
	1.5	22.5	3.0	6.2	105	D-3	0	25.0	8.0	7.0	94
	2.5	20.0	0.4	6.3	120		1.5	22.5	4.7	6.4	91
D-3	0	25.0	8.0	7.0	94		2.7	20.0	0.3	6.4	120
	1.5	22.5	4.7	6.4	91						
	2.7	20.0	0.3	6.4	120						

TABLE 1 - (continued)

July 28, 1977													
STATION	Depth Meters	Temp °C	DO	mg/l pH	Cond. µmhos	Alk. mg/l	STATION	Depth Meters	Temp °C	DO	mg/l pH	Cond. µmhos	Alk. mg/l
A-1	0	27.5	6.9	6.7	135	35.6	R	0	25.5	6.7	6.5	215	58.7
	1.5	27.0	6.4	6.6	135	-		1.5	24.0	3.4	6.4	190	-
	3.0	25.5	4.8	6.5	130	-		2.0	23.5	4.4	6.4	180	-
	3.5	24.5	3.8	6.4	145	34.5							
A-2	0	26.8	6.3	6.6	135	35.3	E	0	25.0	6.0	6.5	220	64.9
	1.5	26.5	5.8	6.6	135	-		1.4	24.0	2.7	6.3	210	-
	3.0	25.5	4.8	6.5	130	-	F	0	24.2	4.6	6.5	240	76.9
	4.0	17.5	1.2	6.4	205	34.9		1.2	23.5	2.5	6.4	235	-
A-3	0	26.2	6.7	6.6	140	35.3	M	0	27.0	7.0	6.5	150	36.7
	1.5	26.0	6.0	6.5	130	-		1.5	26.0	6.2	6.4	140	-
	3.0	25.5	5.3	6.5	130	-		2.4	25.1	6.0	6.4	135	37.2
	4.0	17.5	1.2	6.4	190	28.9							
B-1	0	26.5	7.3	6.7	150	36.8	N	0	26.5	7.0	6.5	150	38.1
	1.5	25.8	5.6	6.6	140	-		1.5	25.5	5.3	6.4	140	-
	3.0	25.0	3.7	6.3	140	-		2.2	25.0	2.6	6.2	140	36.7
	4.0	19.5	0.2	6.2	240	43.1							
B-3	0	26.7	7.0	6.6	140	36.2	P	0	26.5	5.9	6.4	155	37.6
	1.5	26.0	6.3	6.5	140	-		1.5	25.0	4.8	6.3	150	35.9
	3.0	24.5	2.2	6.2	140	-		0	27.3	6.9	6.6	140	36.1
	4.5	15.5	0.7	6.8	240	-		1.5	25.7	5.2	6.5	140	-
C-1	0	26.7	7.4	6.5	150	38.2	Q	3.0	25.0	3.3	6.4	140	-
	1.5	25.5	4.3	6.3	145	-		4.0	17.0	0.2	6.2	250	39.8
	2.5	25.2	3.8	6.3	140	37.6		0	27.0	7.5	6.6	150	38.1
								1.5	26.0	6.8	6.5	145	37.7
C-3	0	26.5	6.3	6.5	150	38.0							
	1.5	25.3	5.7	6.4	140	-							
	2.0	25.0	5.5	6.3	140	37.8							
D-1	0	25.7	6.2	6.6	160	39.2							
	1.5	25.0	6.0	6.5	150	-							
	2.5	24.5	5.9	6.3	150	40.0							
D-2	0	25.5	6.8	6.4	150	37.8							
	1.5	25.0	6.5	6.4	150	38.0							
D-3	0	26.0	6.2	6.4	150	38.4							
	1.5	25.3	5.0	6.3	150	-							
	2.1	25.1	3.9	6.2	150	38.6							

NOTE: Stations B-2 and C-2 were dropped from the sampling network because data from the other two stations on the transect were sufficient to characterize water quality.

TABLE 2
PHYSICAL AND CHEMICAL WATER QUALITY CHARACTERISTICS
PARKER CREEK BASIN

March 3, 1977						March 17, 1977					
STATION	Depth Meters	Temp °C	DO mg/l	pH	Cond. µmhos	STATION	Depth Meters	Temp °C	DO mg/l	pH	Cond. µmhos
A-1	0	12.0	9.2	6.8	72	A-1	0	16.5	8.2	6.6	63
	1.5	10.5	9.0	6.8	72		1.5	15.7	7.7	6.5	60
	2.4	10.0	8.8	6.7	72		2.5	15.0	7.0	6.6	63
A-2	0	11.5	9.2	6.8	72	A-2	0	17.1	8.1	6.6	64
	1.5	10.5	9.1	6.8	72		1.5	15.8	7.5	6.6	62
	3.0	10.0	7.4	6.7	66		3.0	11.8	0.3	6.4	75
	3.3	10.0	6.4	6.6	70	A-3	0	17.5	8.4	6.6	62
A-3	0	11.7	9.2	6.8	73		1.5	16.0	7.5	6.5	61
	1.5	10.5	8.9	6.8	72		3.0	11.5	0.3	6.4	75
	3.0	10.1	6.8	6.8	73	B-1	0	17.5	8.3	6.6	61
	3.3	10.0	3.4	6.5	76		1.5	15.8	7.1	6.4	58
B-1	0	11.5	9.1	6.8	72	B-2	0	17.5	8.3	6.6	63
	1.5	10.4	9.0	6.7	71		1.5	15.3	7.1	6.5	57
	1.9	10.0	8.2	6.5	60	B-3	0	17.5	8.4	6.6	64
B-2	0	11.5	9.0	6.8	73		1.5	14.5	6.0	6.3	55
	1.5	10.5	8.3	6.7	71		2.5	13.3	2.4	6.2	53
	2.5	9.9	6.9	6.4	64	C	0	17.0	8.4	6.7	52
B-3	0	12.0	9.2	6.8	73		1.5	12.5	4.0	6.3	61
	1.5	10.5	8.9	6.7	72	D	0	17.0	8.4	6.5	54
	2.7	9.7	6.3	6.7	61		1.2	14.0	4.3	6.2	46
C	0	11.3	9.2	6.6	61						
	1.5	9.5	8.9	6.6	56						
D	0	13.0	9.4	6.3	62						
	1.3	9.6	7.2	6.1	46						

TABLE 2 - (continued)

April 29, 1977						May 20, 1977					
STATION	Depth Meters	Temp °C	DO mg/l	pH	Cond. μmhos	STATION	Depth Meters	Temp °C	DO mg/l	pH	Cond. μmhos
A-1	0	19.3	6.3	6.6	88	A-1	0	27.7	7.7	7.4	96
	1.5	19.3	6.1	6.5	84		1.5	24.8	2.7	6.4	99
	1.7	19.1	6.0	6.5	87						
A-2	0	19.0	6.6	6.6	80	A-2	0	27.7	7.7	7.1	93
	1.5	18.9	6.6	6.5	78		1.5	24.2	3.8	6.5	94
	3.0	15.0	0.1	6.3	120		3.0	16.5	0.0	6.6	190
A-3	0	19.0	6.4	6.6	86	A-3	0	27.0	8.0	7.1	90
	1.5	18.5	6.1	6.6	86		1.5	24.2	4.0	6.2	91
	3.0	15.0	0.2	6.5	110		3.0	17.0	1.2	6.2	180
	3.5	14.2	0.1	6.5	150	B-1	0	26.5	7.2	7.1	91
B-1	0	19.5	6.7	6.6	87		1.5	24.8	5.4	6.6	93
	1.5	19.3	5.9	6.5	84		2.4	20.0	0.7	6.5	180
	2.0	18.3	0.1	6.4	180	B-2	0	27.0	7.6	6.9	89
B-2	0	19.5	6.1	6.6	86		1.5	24.5	4.7	6.3	92
	1.5	19.3	5.7	6.5	87	B-3	0	28.0	7.7	7.0	90
	2.0	18.3	0.4	6.2	150		1.5	25.8	5.7	6.6	96
B-3	0	19.5	6.1	6.5	81	C	0	28.5	5.5	6.6	95
	1.5	19.5	6.0	6.5	80		1.2	25.2	1.5	6.5	130
	1.7	19.3	5.9	6.4	84	D	0	28.5	6.1	7.6	105
C	0	19.2	4.3	6.5	110		1.0	26.0	3.6	6.5	110
	1.5	18.5	0.7	6.3	140						
D	0	19.5	4.4	6.4	93						
	1.5	18.8	0.5	6.1	125						
	1.8	17.8	0.2	6.1	280						

TABLE 2 - (continued)

July 28, 1977						
STATION	Depth Meters	Temp °C	DO mg/l	pH	Cond. µmhos	Alk. mg/l
A-1	0	29.5	9.3	7.0	160	51.2
	0.8	28.7	8.8	6.9	150	43.6
A-2	0	28.0	9.6	7.0	160	50.6
	1.5	26.0	5.7	6.7	150	-
	2.6	24.5	0.2	6.3	260	49.5
A-3	0	28.8	9.4	7.0	165	52.6
	1.5	26.3	5.9	6.8	150	-
	2.7	23.5	0.3	6.3	250	52.2
B-1	0	29.2	9.1	7.0	160	52.8
	1.5	25.7	4.7	6.7	150	-
	2.5	24.5	0.5	6.3	320	47.0
B-2	0	29.0	8.9	6.9	155	47.7
	1.5	26.0	4.2	6.7	145	47.3
B-3	0	29.3	8.5	6.9	150	48.8
	1.0	26.5	5.2	6.6	150	48.0
C	0	30.5	11.8	6.9	155	48.3
	0.5	28.3	8.2	6.6	150	-
D	0	29.6	9.1	6.8	160	46.4
	0.8	27.5	8.0	6.6	150	-

April was not as persistent and showed a higher degree of vertical change later in the summer. The mean values on each date of sampling for pH and conductivity determinations at all stations in each basin are summarized in Table 3. The seasonal changes that have been described above are clearly indicated.

Mercury in Water

The results of the replicate water samples analyzed for mercury, using procedures with a detection limit at 0.20 ppb, showed a consistent pattern in which a large number of samples were below the detection limit (Tables 4 and 5). Those samples that had levels of detectable mercury were found primarily on two sampling dates. This pattern was noted in the water samples from both impoundments. In the case of Beaverdam, those water samples taken in December 1976 and March 1977, were the only ones in which there were samples that were systematically above the detection limit. Most were in the range of approximately 3-4 times the detection limit or slightly less than 1 part per billion. A scattering of samples, greater than 0.2 ppb, were also found in the May 20, 1977 samples. In the last set of samples July 1977, all samples, surface and bottom, at all stations, were less than the detectable limit. A comparable pattern of water samples with mercury slightly above the detection limit, for a short period, subsequent to the filling of the impoundment, also appeared at Parker Creek. These were the samples collected in April and May 1977. One water sample did have mercury at greater than the detection limit in March, but this was so much higher (2.0 ppb) than other determinations, that it would appear to be anomalous. No other samples on that sampling date were above the detection limit.

Assembling the results of the mercury analyses from those dates which had mercury concentrations above the detection limit, as mean values for all stations, surface and bottom separately, the averages for each basin can be compared (Table 6). On the dates of measurable concentration, the waters of Beaverdam were at a concentration of mercury about 1.5 greater than the waters of Parker Creek Reservoir. The standard deviations for these values provide an indication of the degree of variability between the samples used in the computation of the mean. At Beaverdam, the concentrations of mercury in the surface waters were slightly lower than the bottom samples, but both surface and bottom samples were approximately the same magnitude larger than found in the Parker Creek samples. However, in all instances, except for the one anomaly noted, all measurable concentrations were far below the limits set for potable

TABLE 3
Mean Values - Water Quality Parameters

	0 - 1.5 M						>1.5 M					
	Temp. °C	DO mg/l	DO % Sat	pH	Cond. µmhos	Atk. mg/l	Temp. °C	DO mg/l	DO % Sat	pH	Cond. µmhos	Atk. mg/l
BEAVERDAM												
Sample Date												
12/22/76	4.8	9.4	73.3	6.7	74	-	4.8	9.2	73.8	6.7	76	-
3/17/77	15.5	8.2	81.9	6.5	68	-	11.9	4.5	41.5	6.4	76	-
5/20/77	24.9	7.7	91.4	6.9	100	-	18.9	2.9	30.4	6.3	114	-
7/28/77	25.8	6.8	82.4	6.5	157	41.4	22.5	3.2	36.6	6.2	168	37.5
PARKER CREEK												
Sample Date												
3/03/77	11.0	8.9	80.5	6.7	68	-	10.0	6.8	59.7	6.6	68	-
3/17/77	16.1	7.4	75.1	6.5	60	-	12.9	2.5	23.5	6.4	67	-
4/29/77	18.8	5.0	53.2	6.5	92	-	17.1	1.6	16.8	6.4	145	-
5/20/77	26.3	5.6	67.8	6.8	97	-	17.8	0.6	6.6	6.4	183	-
7/28/77	28.1	7.9	100.0	6.8	154	48.8	24.2	0.3	3.9	6.3	277	49.6

TABLE 4

Beaverdam Creek Reservoir

Mercury - micrograms/liter

(No. in parenthesis is standard deviation of replicate samples if concentration was above detection limit)

Lake Stations	Oct. 2, 1976 ^a		Dec. 22, 1976 ^b		March 17, 1977 ^c		May 20, 1977 ^d		July 28, 1977 ^e	
	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
A-1	<0.20	-	0.36(.06)	0.40(.14)	<0.20	0.30(.00)	<0.20	<0.2	<0.20	<0.20
A-2	<0.20	-	0.32(.04)	0.40(.11)	<0.20	<0.20	<0.20	<0.2	<0.20	<0.20
A-3	<0.20	-	0.40(.10)	0.52(.07)	<0.20	0.45(.01)	0.48(.02)	<0.2	<0.20	<0.20
P	<0.20	-	0.34(.06)	0.67(.11)	0.33(.04)	<0.20	<0.20	<0.20	<0.20	<0.20
B-1	<0.20	<0.20	0.31(.06)	0.57(.17)	<0.20	0.58(.08)	<0.20	<0.20	<0.20	<0.20
B-2	<0.20	-	-	-	-	-	-	-	-	-
B-3	-	-	0.42(.06)	0.29(.01)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Q	<0.20	-	0.28(.05)	0.45(.09)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
C-1	-	-	0.86(.06)	0.36(.06)	0.28(.01)	0.53(.00)	<0.20	<0.20	<0.20	<0.20
C-2	<0.20	-	-	-	-	-	-	-	-	-
C-3	-	-	0.27(.06)	0.55(.03)	0.40(.02)	<0.20	0.25(.07)	0.48(.28)	<0.20	<0.20
D-1	-	-	0.41(.06)	0.55(.02)	0.23(.02)	<0.20	<0.20	<0.20	<0.20	<0.20
D-2	-	-	0.49(.04)	0.48(.03)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
D-3	-	-	0.40(.05)	0.25(.00)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
R	<0.20	-	-	-	<0.20	-	<0.20	<0.20	<0.20	<0.20
E	-	-	-	-	<0.20	-	<0.20	<0.20	<0.20	<0.20
F	-	-	-	-	0.53(.02)	-	0.23(.00)	<0.20	<0.20	<0.20

TABLE 4 (continued)

Stream Stations	Oct. 2, 1976 ^a		Dec. 22, 1976 ^b		March 17, 1977 ^c		May 20, 1977 ^d		July 28, 1977 ^e	
	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
M	< 0.20	-	0.34(.01)	0.65(.07)	<0.20	0.78(.01)	<0.20	<0.20	<0.20	<0.20
N	< 0.20	-	0.28(.07)	0.43(.12)	0.73(.00)	0.40(.00)	<0.20	<0.20	<0.20	<0.20
O	< 0.20	-	0.22(.06)	0.50(.10)	0.48(.07)	0.28(.00)	<0.20	<0.20	<0.20	<0.20

a-e

Detection limit and replicate size, N, at time of sample

a - 0.2µg/l; N-2

c - 0.2µg/l; N-3

b - 0.2µg/l; N-2

d - 0.2µg/l; N-3

e - 0.2µg/l; N-3

TABLE 5
Parker Creek Reservoir

Mercury - micrograms/liter

(No. in parenthesis is standard deviation of replicate samples if concentration was above detection limit)

Stations	March 3, 1977 ^a		March 17, 1977		April 29, 1977		May 20, 1977		July 28, 1977	
	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
A-1	<0.20	<0.20	<0.20	<0.20	0.28(.15)	<0.20	0.31(.03)	<0.20	<0.20	<0.20
A-2	<0.20	<0.20	<0.20	<0.20	0.29(.00)	0.26(.18)	0.24(.01)	<0.20	<0.20	<0.20
A-3	<0.20	<0.20	<0.20	<0.20	0.29(.01)	0.31(.06)	<0.20	<0.20	<0.20	<0.20
B-1	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
B-2	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
B-3	<0.20	<0.20	<0.20	<0.20	0.31(.03)	<0.20	<0.20	<0.20	<0.20	<0.20
C	<0.20	-	2.0(.07)	-	<0.20	<0.20	0.21(.02)	<0.20	<0.20	<0.20
D	<0.20	-	<0.20	-	<0.20	<0.20	<0.20	0.27(.02)	<0.20	<0.20

^aDetection limit on all samples - 0.2µg/l; replicate size - 3

TABLE 6

Mean Values and Standard Deviation of All Water Samples
With Measurable Amounts of Mercury (>0.20 ppb) on Date of Samples

	Surface		Bottom	
	<u>ppb</u>	<u>S.D.</u>	<u>ppb</u>	<u>S.D.</u>
Beaverdam				
12/22/76	0.38	.15	0.47	.12
03/17/77	0.42	.17	0.47	.17
Parker Creek				
04/29/77	0.29	.01	0.28	.03
05/20/77	0.25	.05	0.27	-

water supplies.* This pattern of appearance and disappearance of mercury in the waters of the two impoundments, and not specifically associated with some unusual limnological characteristic of the waters, appeared to indicate that the appearance and disappearance of mercury followed a time sequence subsequent to the submergence of the bottom of the basin. If an approximate flooding date of August 1, 1976, for Beaverdam and December 1, 1976, for Parker Creek is used, based both on observational and rainfall records, there was a clearly indicated increase in the percent of the total number of water samples analyzed on each sampling date that exceeded the detection limit of 0.20 ppb as well as absolute average concentration. This increase was followed by a subsequent decline (~100-150 days) until all samples were once more below limits of detection. If the percent of water samples that analyzed greater than the detection limit is plotted against days post-closure, an approximation of a time limiting factor is indicated (Figure 5). In both basins, the maximum number of samples that exceeded the detection limit for mercury occurred in a period of 140-150 days after start of filling. Since the two basins did not fill simultaneously, nor were they sampled on similar dates, that such a coincidence of peaking should be found would indicate that a similar process of release of mercury from soil or plant residues was functioning in both instances.

Soil Core Analyses

The results of the analyses which describe each soil core (sets of three at each sampling point) at three core depths in terms of percentage of sand, silt, clay, water and organic matter, as well as the mercury content for each of the fractions is presented in Table 7 (Beaverdam) and Table 8 (Parker Creek). In these replicate samples, the percent composition and mercury content are also defined with regard to variability by the c.v. (coefficient of variation). These c.v.'s tend to be quite low considering the nature of the analyses and indicate a high degree of commonality between the replicate samples. It is worth noting that in some transects, e.g., Beaverdam A, the cores were high in sand and low in organic matter, whereas, The B-transect, Station 2 was consistently more silty and also had a higher organic content. The latter appears to be associated with higher mercury values. In some instances, in very sandy cores such as B-3, the mercury content was quite low, a reverse of what was found at the B-2 location. It would appear in generalization that the higher mercury values tended to be associated with the higher organic values. The

*2.0 mg/l for domestic water supply (USEDA, 1976. Quality Criteria for Water).

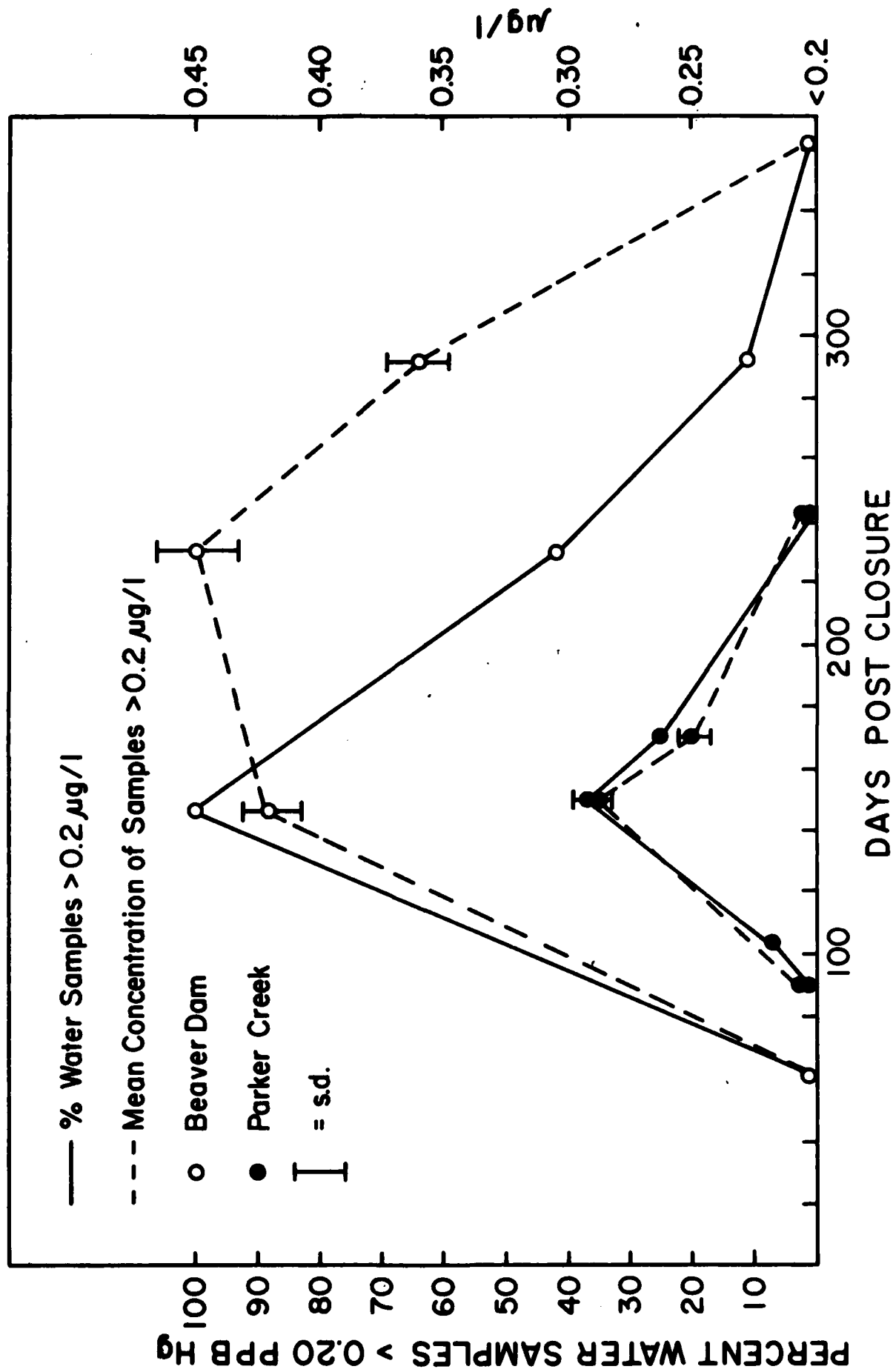


Figure 5. Relationship of percent of samples greater than mercury detection limit and absolute mercury concentration with days post closure of Beaver Dam and Parker Creek, December.

TABLE 7.
Beaverdam Reservoir
Soil Core Analysis (Percent Composition) and Mercury Content (ppb)
Mean Values of Triplicate Cores

STATION	Core Depth Cm	SAND			SILT			CLAY			WATER			ORGANIC MATTER			Hg ppb	c.v.
		c.v.	c.v.	c.v.	c.v.	c.v.	c.v.	c.v.	c.v.	c.v.	c.v.	c.v.	c.v.	c.v.	c.v.	c.v.		
A-1	0 - 5	57.5	3.0	1.5	29.5	1.5	9.9	18.0	15.9	8.0	1.29	19.1	33.0	10.5				
	5 - 10	48.8	15.5	6.8	34.4	6.8	12.7	37.7	16.4	3.4	1.53	30.7	42.6	23.1				
	10 - 15	45.7	4.3	14.1	35.1	14.1	15.3	31.0	15.5	4.4	1.55	15.4	45.0	42.4				
A-2	0 - 5	50.4	14.7	9.9	26.9	9.9	18.8	31.3	23.7	12.4	2.70	22.9	38.3	30.5				
	5 - 10	55.8	4.5	12.8	24.9	12.8	16.3	11.0	16.3	4.4	2.96	27.3	51.0	27.7				
	10 - 15	50.7	10.9	17.0	27.9	17.0	17.8	11.0	14.3	8.6	3.07	39.8	56.6	19.0				
A-3	0 - 5	46.9	7.9	3.0	32.8	3.0	17.5	8.8	14.1	17.9	1.97	12.8	14.6*	55.1				
	5 - 10	43.3	20.3	18.1	32.2	18.1	19.4	16.6	13.3	2.6	2.19	17.7	22.0	7.9				
	10 - 15	48.4	5.2	12.3	31.2	12.3	16.5	22.7	12.2	18.5	2.21	43.3	27.3*	62.2				
B-1	0 - 5	48.1	3.8	1.6	35.3	1.6	10.6	12.3	16.9	20.0	2.61	24.4	31.0	43.4				
	5 - 10	48.1	1.6	7.9	36.0	7.9	10.8	15.2	17.0	17.9	2.16	5.5	23.6	10.6				
	10 - 15	50.3	1.4	6.5	36.7	6.5	10.5	12.5	17.9	8.9	2.19	34.7	24.3	18.5				
B-2	0 - 5	17.5	21.6	9.3	46.8	9.3	30.7	16.5	39.1	29.3	4.20	7.2	84.6	26.8				
	5 - 10	17.9	17.8	4.2	46.6	4.2	30.3	9.6	20.6	12.8	4.20	20.1	72.6	13.8				
	10 - 15	20.2	6.0	1.5	46.0	1.5	28.0	6.8	19.7	2.2	3.66	13.5	62.6	24.0				
B-3	0 - 5	59.7	7.7	15.1	22.0	15.1	8.5	39.8	14.1	38.7	4.44	90.8	54.6	69.2				
	5 - 10	65.1	15.1	11.9	22.3	11.9	9.6	60.8	15.9	51.7	3.19	100.8	49.0	53.6				
	10 - 15	55.2	3.1	8.1	28.6	8.1	13.3	22.0	16.2	47.1	2.15	14.5	57.3	45.8				

* These mean values include one or more replicates that were < the detection limit of 20 ppb.
To compute a mean of the replicates which included such samples, a value of 10 ppb was assigned to them in the calculation.

TABLE 7
Beaverdam Reservoir
Soil Core Analysis (Percent Composition) and Mercury Content (ppb)
Mean Values of Triplicate Cores

STATION	Core Depth Cm	SAND			SILT			CLAY			WATER			ORGANIC MATTER			Hg	
			c.v.			c.v.		c.v.		c.v.		c.v.		c.v.		ppb	c.v.	
C-1	0 - 5	43.3	13.2	33.5	15.2	20.3	18.1	23.5	2.80	26.2	38.6	17.2						
	5 - 10	37.1	4.0	41.5	7.2	9.2	17.9	11.4	2.85	15.0	44.3	19.2						
	10 - 15	37.1	8.7	37.2	3.7	14.1	18.0	3.2	3.71	11.4	49.0	6.1						
C-2	0 - 5	59.9	30.3	25.4	35.9	53.0	5.0	92.0	3.27	77.8	43.3	57.3						
	5 - 10	70.4	23.8	16.2	72.7	52.8	5.9	59.9	1.64	32.6	36.0	37.4						
	10 - 15	60.0	32.6	23.7	59.0	35.4	9.5	51.9	2.03	49.5	39.6	16.4						
C-3	0 - 5	77.1	3.4	12.6	3.8	4.4	6.3	63.4	1.43	19.8	35.0	5.7						
	5 - 10	73.1	2.4	15.6	32.8	29.5	8.3	21.9	1.65	26.3	30.0	21.8						
	10 - 15	72.9	9.6	15.8	29.3	19.4	8.8	29.7	1.17	31.7	26.0	41.6						
D-1	0 - 5	8.4	43.3	48.5	14.4	1.9	26.9	15.4	8.71	19.7	55.6	61.3						
	5 - 10	3.9	42.9	52.7	5.2	1.7	23.5	1.6	5.51	8.3	53.0	62.2						
	10 - 15	6.9	38.8	49.1	6.6	2.7	21.8	1.0	5.70	6.0	62.6	20.2						
D-2	0 - 5	27.0	15.0	36.2	3.3	11.8	13.6	6.3	5.21	11.1	43.6	47.1						
	5 - 10	25.9	14.9	37.8	7.3	15.5	15.4	15.9	4.13	11.1	41.6	24.3						
	10 - 15	28.9	12.1	39.8	2.8	9.4	15.3	7.0	3.10	26.8	19.0*	21.0						
D-3	0 - 5	92.7	3.9	4.4	43.3	67.0	21.8	7.8	0.35	44.9	11.6*	24.7						
	5 - 10	92.1	1.3	6.2	4.9	88.1	16.5	9.8	0.29	62.1	10.0*	0.0						
	10 - 15	92.1	2.3	5.4	15.3	52.1	12.9	21.4	0.22	36.2	15.6*	62.6						

* These mean values include one or more replicates that were < the detection limit of 20 ppb. To compute a mean of the replicates which included such samples, a value of 10 ppb was assigned to them in the calculation.

TABLE 7
Beaverdam Reservoir
Soil Core Analysis (Percent Composition) and Mercury Content (ppb)
Mean Values of Triplicate Cores

STATION	Core Depth Cm	ORGANIC MATTER					Hg				
		SAND	c.v.	SILT	c.v.	CLAY	c.v.	WATER	c.v.	ppb	c.v.
E-1	0 - 5	11.4	64.8	37.8	5.9	48.6	19.6	20.3	8.0	37.0	42.5
	5 - 10	14.7	47.2	37.7	3.3	44.1	19.5	19.7	15.7	39.0	29.5
	10 - 15	23.5	10.2	39.9	12.5	34.1	12.7	18.6	11.5	12.3*	32.8
E-2	0 - 5	66.4	17.4	21.5	38.2	10.0	24.9	10.9	24.4	27.6	19.9
	5 - 10	83.7	3.5	10.4	2.4	5.1	35.8	7.5	45.2	10.0*	0.0
	10 - 15	79.5	8.4	14.9	36.3	5.3	33.4	11.1	43.1	10.0*	0.0
E-3	0 - 5	83.5	0.6	9.9	16.1	6.5	14.8	4.3	29.9	24.6*	63.1
	5 - 10	86.4	1.8	7.6	6.5	5.3	13.9	4.1	6.5	23.0*	97.9
	10 - 15	79.7	5.0	10.5	28.0	7.5	13.3	6.3	20.5	25.6*	62.4
F-1	0 - 5	41.3	46.9	36.0	35.2	18.9	41.7	20.7	12.0	58.6	29.8
	5 - 10	45.2	26.3	35.5	22.8	15.7	21.3	16.9	13.6	53.6	19.9
	10 - 15	51.6	16.7	29.1	18.4	16.2	17.7	16.8	2.1	56.3	29.7
F-2	0 - 5	12.8	34.2	46.0	14.6	40.0	6.3	18.3	3.4	73.3	55.7
	5 - 10	25.5	7.9	41.8	3.7	28.8	18.3	17.3	6.4	75.7	6.6
	10 - 15	31.0	1.4	36.9	3.3	28.2	5.9	16.1	4.2	57.0	53.4
F-3	0 - 5	5.9	7.3	45.1	14.2	49.5	6.9	26.3	8.8	74.0	27.0
	5 - 10	9.7	42.2	38.5	4.9	50.1	7.3	24.9	2.5	77.3	10.8
	10 - 15	9.7	15.0	32.5	8.2	57.6	4.2	24.5	3.2	86.3	9.0

* These mean values include one or more replicates that were < the detection limit of 20 ppb.
To compute a mean of the replicates which included such samples, a value of 10 ppb was assigned to them in the calculation.

TABLE 8
Parker Creek Reservoir
Soil Core Analysis (Percent Composition) and Mercury Content (ppb)
Mean Values of Triplicate Cores

STATION	Core Depth Cm	SAND			SILT	c.v.	CLAY			WATER	c.v.	ORGANIC MATTER	c.v.	Hg	
			c.v.					c.v.	ppb					c.v.	
A-1	0 - 5	35.9	4.8	52.3	9.6	8.0	52.0	11.7	20.0	3.96	32.8	59.3	5.1		
	5 - 10	30.2	11.0	55.2	3.3	12.8	29.2	14.7	11.2	2.92	48.9	25.0*	66.8		
	10 - 15	25.4	10.8	54.2	1.3	18.6	15.2	13.3	8.8	3.09	24.6	10.0*	0.0		
A-2	0 - 5	23.4	17.5	56.7	8.0	17.6	11.8	23.3	10.1	5.14	7.1	34.3	23.4		
	5 - 10	34.5	4.4	47.4	5.5	16.8	20.8	16.8	36.4	3.74	38.9	36.3*	66.1		
	10 - 15	32.1	10.6	46.2	4.6	21.2	10.9	15.6	11.2	2.68	6.5	21.3*	25.8		
A-3	0 - 5	21.2	31.8	57.4	9.6	19.4	17.4	19.5	11.4	5.40	12.9	60.3	31.2		
	5 - 10	22.6	37.3	53.7	7.3	19.2	28.0	19.9	15.3	4.14	23.6	48.6	22.7		
	10 - 15	24.0	32.1	53.0	8.5	21.1	21.4	19.8	5.9	3.64	25.0	50.7	19.8		
B-1	0 - 5	4.2	43.3	68.9	1.4	26.3	1.4	20.3	10.4	3.98	22.7	54.0	18.3		
	5 - 10	11.0	42.4	62.5	6.8	25.7	6.2	24.3	6.8	5.67	4.5	78.0	3.6		
	10 - 15	7.9	29.8	64.9	4.0	27.7	4.2	23.2	9.1	5.14	14.6	73.0	9.7		
B-2	0 - 5	6.2	21.4	72.0	3.5	22.4	10.0	21.2	7.0	3.19	11.9	55.3	27.1		
	5 - 10	5.6	4.5	69.8	1.9	24.5	6.8	17.3	5.0	2.53	5.7	29.3	51.1		
	10 - 15	5.6	13.6	68.3	1.9	25.5	5.9	17.6	2.4	2.58	21.0	39.3	18.4		
B-3	0 - 5	13.3	8.3	65.0	8.1	18.0	14.5	17.1	13.2	2.97	18.1	46.7	23.5		
	5 - 10	10.6	24.2	67.9	4.0	19.6	22.8	17.2	1.7	2.69	17.7	45.0	25.6		
	10 - 15	11.2	16.1	65.9	5.3	22.0	16.8	17.0	1.0	2.77	3.2	19.7*	50.9		

* These mean values include one or more replicates that were < the detection limit of 20 ppb.
To compute a mean of the replicates which included such samples, a value of 10 ppb was assigned to them in the calculation.

TABLE 8
Parker Creek Reservoir
Soil Core Analysis (Percent Composition) and Mercury Content (ppb)
Mean Values of Triplicate Cores

STATION	Core Depth Cm	SAND		SILT		CLAY		WATER		ORGANIC MATTER		Hg	
		c.v.		c.v.		c.v.		c.v.		c.v.		c.v.	ppb
C-1	0 - 5	7.1	8.0	64.7	2.7	26.1	2.5	19.2	11.8	6.76	6.6	49.5	18.6
	5 - 10	9.0	28.0	63.8	3.0	23.7	7.0	17.3	2.5	4.20	10.2	40.5	26.2
	10 - 15	9.0	2.9	66.5	1.3	22.4	1.5	16.1	8.5	3.49	6.2	44.0	54.6
D-1	0 - 5	2.8	41.3	73.7	3.5	22.2	4.7	30.2	3.6	5.35	28.7	101.5	49.5
	5 - 10	43.7	10.5	43.9	11.2	10.7	18.4	20.4	6.3	2.11	17.0	37.5	35.8
	10 - 15	35.3	5.9	46.7	7.0	16.0	5.2	18.1	9.9	3.48	13.3	30.5	2.3

core analyses from Parker Creek also supports this relationship, although it is not quite as sharply defined as it is from Beaverdam cores. However, as a further test of the possible correlations between mercury concentrations and the composition of the soils this relationship is examined overall for all samples and separately at each core depth for the Beaverdam and Parker Creek samples, Table 9. The strong negative correlations with the quantity of sand and mercury is consistent in all samples as well as the strong positive correlation, with high probability, between mercury and the organic content of the soil, both overall as well as for core depth segments. The strong correlations are clear in the Beaverdam cores but not quite as clear in the Parker Creek samples. Overall, Parker Creek has a strong correlation with organic content but by specific core depths it is not quite as consistent, particularly in the surface samples as are the Beaverdam cores. In both Beaverdam and Parker Creek, overall there is a consistent pattern of decreasing mercury content with depth, the gradient being somewhat sharper in Parker Creek than in Beaverdam. These values of mercury in soil, 30-50 ppb are consistent with other published determinations for sediments from non-polluted areas (Förstner, 1977; D'Itri et al. 1978).

Mercury in Plant Tissues

The determination of mercury in the plant material harvested from the lake bottom, prior to flooding, proved to be somewhat more difficult than expected. The problem was one of obtaining complete digestion of the organic material to insure full release of whatever mercury might be present. Incomplete digestion exaggerated foaming and carry over in the gas stripping of the final analytical step. Eventually, it was determined that complete digestion could best be insured by heating under pressure (autoclaving) with the acid digestion solution and persulfate. However, even with this vigorous treatment, some plant materials were still not completely digested.

At the time of taking the plant samples, the grasses and sedges particularly were not at a flowering season, essential for full identification. The final sorting and identification was therefore, limited to major groups of plants and within each of these, identification of all obviously similar taxa. This broad taxonomic sorting established that there were seven different grasses, five sedges, one species of the Juncaceae and three different species of herbaceous plants in the plant collections. The plant material that had been frozen when collected was thawed, air dried, pulverized to facilitate digestion, and then digested and analyzed for mercury. In some instances,

Table 9

Correlation Coefficients, Mercury Concentration and Percent Soil Composition
Overall and at Three Core Depths

BEAVERDAM							Mean Values *	
	N	Sand	Silt	Clay	H ₂ O	Organic Matter	Mercury- ppb	Std. Dev.
Overall	54 prob.	-0.677 -0.0001	0.619 0.0001	0.640 0.0001	0.580 0.0001	0.708 0.0001	42.0	20.3
Core Depth 0 - 5 cm	18 prob.	-0.715 0.0009	0.713 0.0009	0.626 0.0055	0.575 0.0126	0.699 0.0012	43.3	20.1
5 - 10	18 prob.	-0.729 0.0006	0.695 0.0014	0.681 0.0019	0.637 0.0045	0.768 0.0002	41.9	20.4
10 - 15	18 prob.	-0.591 0.0098	0.448 0.0620	0.6178 0.0063	0.620 0.0060	0.681 0.0019	40.7	21.6
PARKER CREEK								
Overall	24 prob.	-0.406 0.0486	0.423 0.0393	0.268 0.2052	0.726 0.0001	0.619 0.0013	45.4	20.1
Core Depth 0 - 5	8 prob.	-0.336 0.4160	0.493 0.2147	0.092 0.8283	0.541 0.1661	0.154 0.7158	57.6	19.6
5 - 10	8 prob.	-0.315 0.4475	0.163 0.6990	0.514 0.1920	0.881 0.0038	0.798 0.0177	42.5	16.3
10 - 15	8 prob.	-0.474 0.2357	0.374 0.3616	0.667 0.0707	0.899 0.0024	0.810 0.148	36.1	20.1

* Mean of triplicate Hg determinations at each core depth of each of three cores,
at each station location.

with only a limited quantity of a plant sample available and resisting digestion, that particular sample provided no information as to mercury content. In other instances, even with complete digestion no detectable amount of mercury was found.

As noted in Table 10, there is a strong indication that the mercury content of the sedges is greater than the grasses. The few specimen of the Juncaceae were in a range between the grasses and the sedges whereas the herbaceous plants tend to be at the lower end of the scale even lower than grasses. A comparison of the plant mercury concentrations and that of the top 5 cm of the soil from which the specimens were taken showed concentration factors that reflected the differences in mean levels of mercury in the four plant types. The herbaceous samples had a concentration factor of 5.6, the grasses and Juncaceae 6.0 and the sedges 7.4. These concentrations of mercury in plant material are consistent with the literature (D'Itri et al., 1978).

When the plant samples are arranged in rank order according to their mercury content with the associated soil mercury concentration, the plant samples can be clustered in ranges and a mean value of mercury content determined for each cluster, Table 11. The relationship of the clustered mean is shown in Figure 6. This analysis confirms that the plant materials have a mercury content approximately 5-7 times that of the soil from which they originated. The linear correlation between these mean values has an r value of 0.643 with a slope of 13.67. The curve as drawn in the figure is fitted from the regression analysis.

TABLE 10
Mercury in Plant Samples Collected in Beaverdam and Parker Creek Basins

Plant Type	Sample	Location	Hg - ppb Mean ¹	Hg - ppb S.D.	Hg - ppb Soil, Top 5cm	Mean, all samples with Detectable Hg	Mean Soil Hg	Concentration Factor
Grasses								
Species #1	A	BV A-1	240	152.7	33.0	237	39.3	6.0
	B	BV C-1	192	-	38.6			
	C	BV C-3	N.D.	-	35.0			
Species #2	A	BV E-3	N.D.	-	24.6			
	B	PC A-3	228	-	60.3			
Species #3	A	BV C-1	252	11.3	38.6			
	B	BV C-3	144	-	35.0			
Species #6	A	BV E-3	584	90.5	24.6			
Species #7	A	BV D-3	126	20.5	11.6			
	B	BV F-2	132	73.5	73.3			
Sedges								
Species #1	A	BV D-1	348	84.8	55.6	347	46.9	7.4
	B	BV F-1	424	-	58.6			
Species #2	A	BV C-1	106	8.5	38.6			
	B	PC B-3	480	56.5	46.7			
Species #3	A	PC B-2	764	17.0	55.3			
	A	BV A-1	356	50.9	33.0			
Species #4	B	BV B-1	467	-	31.0			
	C	BV B-3	264	-	54.6			
	D	BV C-1	N.D.	-	38.6			
	E	BV C-3	N.D.	-	35.0			
	F	BV D-1	348	84.8	61.3			
	G	BV D-3	218	25.4	11.6			
Species #5	H	BV F-2	260	-	73.3			
	A	BV D-2	128	22.6	43.6			
Juncaceae								
Species #1	A	BV B-3	160	56.5	54.6	279	46.3	6.0
	B	BV D-3	296	-	11.6			
	C	BV F-1	452	107.5	58.6			
	D	PC A-3	210	76.4	60.3			

TABLE 10 (cont'd)
Mercury in Plant Samples Collected in Beaverdam and Parker Creek Basins

Plant Type	Sample	Location	Hg - ppb Mean ¹	Hg - ppb S.D.	Hg - ppb Soil, Top 5cm	Mean, all samples with Detectable Hg	Mean Soil Hg	Concentration Factor
Herbaceae								
Species #1	A	BV D-3	N.D.	-	11.6			
Species #2	A	BV E-1	180	39.6	37.0			
Species #3	A	BV B-1	116	28.3	31.0	148	26.5	5.6

1

When replicate analyses possible on sample, mean value calculated with standard deviation.
N.D. - no detectable mercury at limit of sensitivity.

TABLE 11

Mercury Content of Plant Samples

Arranged in Increasing Order of Concentration (Mean of Duplicate Analysis)
and Compared to Originating Soil Mercury Concentration

Hg ppb	Mean (S.D.)	Plant	Location	Top 5 cm Soil Hg-ppb	Mean(S.D.)
N.D.		Grass #1	(Bv C-3)	35.0	
		Grass #2	(Bv E-3)	24.6	
		Sedge #4	(Bv C-3)	35.0	
		Sedge #4	(Bv C-1)	38.6	
N.D.		Herbaceae #1	(Bv C-1)	11.6	28.9(11.0)
106		Sedge #2	(Bv C-1)	38.6	
116		Herbaceae #3	(Bv B-1)	31.0	
127		Grass #7	(Bv D-3)	11.6	
128		Sedge #5	(Bv D-2)	43.6	
132		Grass #7	(Bv D-3)	11.6	
144		Grass #3	(Bv C-3)	35.0	
160	130.4 (18)	Juncaceae #1	(Bv B-3)	54.6	32.3(19.9)
180		Herbaceae #2	(Bv E-1)	37.0	
192		Grass #1	(Bv C-1)	38.6	
210		Juncaceae #1	(Pk A-3)	60.3	
218		Sedge #4	(Bv D-3)	11.6	
228		Grass #2	(Pk A-3)	54.4	
240	211.3 (22)	Grass #1	(Bv A-1)	33.0	40.1(18.4)
252		Grass #3	(Bv C-1)	41.5	
260		Sedge #4	(Bv F-2)	73.3	
264		Sedge #4	(Bv D-1)	54.6	
348		Sedge #4	(Bv D-1)	55.6	
356	296.0 (51)	Sedge #4	(Bv A-1)	33.0	51.0(15.8)
424		Sedge #1	(Bv F-1)	58.6	
452		Juncaceae #1	(Bv F-1)	58.6	
467		Sedge #4	(Bv B-1)	31.0	
480		Sedge #2	(Pk B-3)	46.7	
584		Grass #6	(Bv E-3)	24.6	
764	528.0 (12)	Sedge #3	(Pk B-2)	55.3	45.8(14.7)

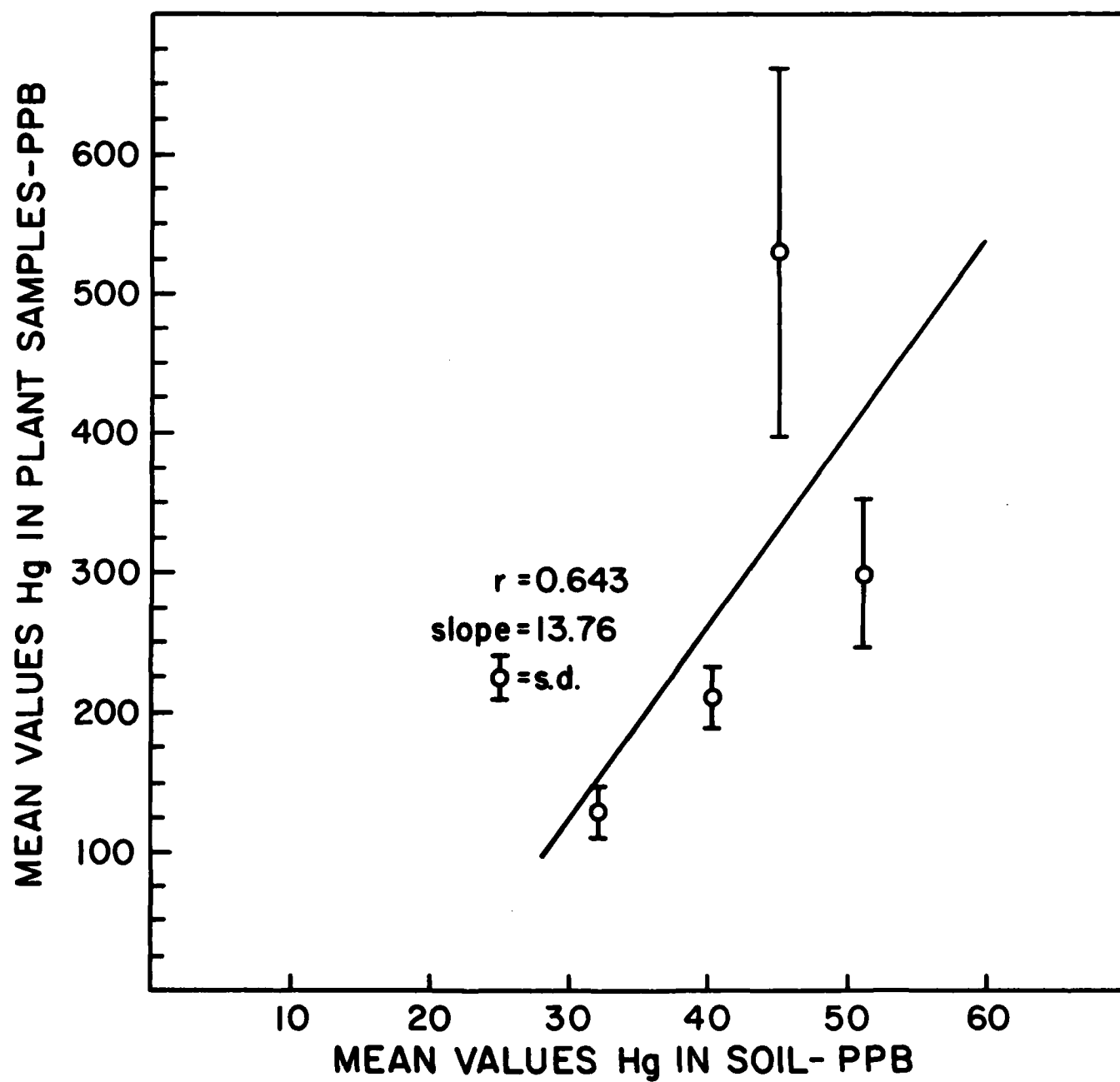


Figure 6. Relationship of mean values of mercury in plant samples and mean values of originating soil samples derived from rank clustering

REFERENCES

- Agemian, H. and S. S. Y. Chau, 1976. An improved method for the extraction of mercury from environmental samples. Analyst 101:91-95.
- D'Itri, Frank M. 1973. Mercury in the aquatic ecosystem. In Gary E. Glass (ed.), Bioassay techniques and environmental chemistry; Ann Arbor Science, Ann Arbor, Michigan. pp. 3-70.
- D'Itri, F. M., A. W. Andren, R. A. Doherty and V. W. Wood. 1978. An assessment of mercury in the environment. National Academy of Sciences, Washington, DC. 185p.
- Förstner, U. 1977. Metal concentrations in freshwater sediments - natural background and cultural effects. In H. L. Golterman (ed.), Interaction between sediments and freshwater. Dr. W. Junk B.V., The Hague pp. 94-107.
- Gross, M. G. 1971. Carbon determination. In R. E. Carver (ed.) Procedures in sedimentary petrology. Wiley-Interscience, New York. pp. 573-596
- Ingram, R. L. 1971. Sieve Analysis. In R. E. Carver (ed.) Procedures in sedimentary petrology. Wiley-Interscience, New York. pp. 49-67.
- Lo, J. M. and C. M. Wai. 1975. Mercury loss from water during storage: Mechanisms and prevention. Analytical Chemistry. 47:1869-1870.
- Miettinen, J. K. 1977. Inorganic trace elements as water pollutants; Their implications to the health of man and the aquatic biota. In F. Coulton and E. Mrak (eds.), Water Quality, Proceedings of an International Forum. Academic Press, New York. pp. 113-136.
- Weiss, C. M., T. W. Yocum and J. E. Minogue. 1972. Further characterization of the water quality of the New Hope and Haw Rivers including benthic macroinvertebrate diversity and trace metal analyses. Water Resources Research Institute, University of North Carolina, Chapel Hill, NC. 178p.

END

FILMED

3-83

DTIC